

NASA TECH BRIEF

Ames Research Center



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

Improved Magnesia for Thermal Control Coatings

Magnesia is often used as the basis pigment for white thermal control coatings on spacecraft. However, the service life of magnesia-based coatings is limited because even low-level space radiation (e.g., 1-keV protons) discolors the white pigments. The radiation-induced discoloration of magnesia was known to be the result of the interaction of radiation with impurities; for example, for a cubic lattice of the MgO type, iron constitutes a characteristic impurity defect in which iron(II)-iron(III) pairs are involved in color formation.

A study of color-center formation in single crystals (high purity) and in commercially available powders of magnesia upon irradiation with 1-keV protons was performed in order to gain understanding of impurity and intrinsic lattice defects which are conducive to the formation of radiation-generated color centers. It was found that discoloring of magnesia by iron(III) can be suppressed nearly completely by heating high-purity magnesia (less than 10 ppm atomic Fe content) at 1200° to 1500°C in nitrogen, hydrogen, or in a vacuum; less pure material does not respond as well.

Magnesia which has been properly processed for use in thermal control coatings should have transition metal contents in concentrations less than 5 to 10 ppm (atomic); furthermore, the valence of the transition metal ions should be largely the reduced state, as can be readily accomplished by chemical reduction procedures. Magnesium oxide single crystal was prepared at an iron(II) concentration of 5×10^{17} atoms per ml and an iron(III) concentration of about 0.4×10^{17} atoms per ml (total iron 5 ppma). Upon irradiation with 1-keV protons (total 2.3×10^{17} protons/cm²), the

estimated solar absorbance ($\alpha_s \approx 0.03$) increased less than about 5%.

The results of the study also revealed that discoloration of pigments by radiation can be reduced markedly by introduction of controlled densities of selected defects. Typical deliberately introduced defects involve impurities, native lattice defects, or a combination of both. For example, increasing the iron content from 2.0 ppma to 541 ppma effectively suppresses radiative discoloration. The iron (II)-iron (III) pairs act as recombination centers for both radiation-generated electrons and holes and, in sufficient concentrations, dominate the color center (coloration) kinetics. However, the iron redox pair (substitutional) imparts an undesirable yellowish coloration to the magnesia. A more desirable ion pair is the ceric-cerous redox system which has a coloration in the near-UV spectrum, but even more desirable is the lattice-defect pair, F-F⁺ which shifts coloration deep into the near UV. The pair can be produced in magnesium oxide in controlled density by additive coloration in magnesium vapor.

Notes:

1. The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price \$3.00
(or microfiche \$0.95)

Reference:

NASA CR-73337 (N69-31983), Study of Color Center Formation in White Powder Compounds.

(continued overleaf)

2. Requests for further information may be directed
to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: TSP 72-10424

Patent Counsel
Mail Code 200-11A
Ames Research Center
Moffett Field, California 94035

Source: Herman Levin, Cedric C. Berggren,
and Willard M. Peffley of
Hughes Aircraft Company
under contract to
Ames Research Center
(ARC-10677)

Patent status:

Inquiries about obtaining rights for the commercial
use of this invention may be made to: